Original Article

Standardised early warning scores in rural interfacility transfers: A pilot study into their potential as a decision-making aid

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Abstract

Introduction: While 12.4% of British Columbians live rurally, only 2.0% of specialists practise rurally, making interfacility transport of high-acuity patients vital. Decision-making aids have been identified as a way to improve the interfacility transfer process. We conducted a pilot study to explore the potential of the Standardised Early Warning Score (SEWS) as a decision-making aid for staff at sending facilities.

Methods: SEWSs were calculated from a database of 418 transfers from sending facilities in rural, small and medium population centres to larger receiving facilities. The SEWSs were compared against one another over time using McNemar's and the Wilcoxon signed-ranks tests. The SEWSs were then tested for their association with six outcomes using Pearson's or Fisher's Chi-squared test and the Mann–Whitney U-test.

Results: While at the sending facility, both the number of SEWSs that was four or greater and the average SEWS decreased over time ($P < 0.001$ for both). A first SEWS of four or greater was predictive of more intervention categories during transport ($P = 0.047$), an adverse event during transport ($P = 0.004$), an adverse event within 30 min of arrival at the receiving facility ($P = 0.004$) and death before discharge from the receiving facility ($P = 0.043$) but not deterioration during transport, or the length of stay at the receiving facility.

Conclusion: Overall, the performance of the SEWS in the context of rural interfacility transport suggests that the tool will have utility in supporting decision-making.

Keywords: Early warning scores, interfacility transfer, interfacility transport, rural Standardised Early Warning Score, Standardised Early Warning Score

Introduction : Alors que 12,4 % des résidents de la Colombie-Britannique vivent en milieu rural, seuls 2,0 % des spécialistes y pratiquent, ce qui rend essentiel le transport entre établissements des patients en état grave. Des outils de prise de décision ont été désignés comme méthode pour améliorer le processus de transfert entre établissements. Dans le cadre d'une étude pilote, nous nous sommes penchés sur le potentiel du score SEWS (*Standardised Early Warning Score*) comme outil de prise de décision à l'intention du personnel des établissements d'origine.

Méthodes : Les scores SEWS ont été calculés dans une banque de données de 418 transferts d'établissements d'origine situés dans des agglomérations rurales

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de petite et moyenne taille vers des établissements de réception plus importants. Les scores SEWS ont été comparés entre eux dans le temps à l'aide des tests de McNemar et *Wilcoxon Signed Ranks*. L'association des scores SEWS à six paramètres d'évaluation a ensuite été testée à l'aide des tests de chi carré de Pearson ou de Fisher et du test de Mann-Whitney.

Résultats : À l'établissement d'origine, le nombre de scores SEWS de quatre et plus et le score SEWS moyen se sont abaissés dans le temps (p < 0,001 dans les deux cas). Un score SEWS initial de quatre et plus prédisait un plus grand nombre de catégories d'interventions durant le transport (p = 0,047), la survenue d'un événement indésirable durant le transport (p = 0,004), la survenue d'un événement indésirable dans les 30 minutes après l'arrivée à l'établissement de réception (p = 0,004), et le décès avant le congé de l'établissement de réception (p = 0,043), mais il ne prédisait pas la détérioration durant le transport ni la durée du séjour à l'établissement de réception.

Conclusion : Dans l'ensemble, le rendement du score SEWS dans le contexte du transport rural entre établissements laisse croire que l'outil serait utile à la prise de décision.

Mots-clés: Early Warning Scores, Standardised Early Warning Score, Standardised Early Warning Score rural, transfert entre établissements, transport entre établissements

INTRODUCTION

Rural British Columbians, defined as those living outside census metropolitan areas or census agglomerations, make up 12.4% of the provincial population,[1] and while 11.6% of family physicians practise rurally, only 2% of specialists in the province do.[2] Only 5% of rural BC hospitals have an intensive care unit (ICU) and just 3% have 24/7 access to a computed tomography (CT) scanner, making interfacility transport of paramount importance in this province.[3] One study found that 31% of trauma patients presenting to rural facilities in Northwestern BC required secondary transfer for higher level care,[4] a pattern repeated in rural settings across the country.[5,6]

A qualitative analysis of the interfacility transfer process from three hospitals in the United States, ranging from rural to urban, found that the availability of a decision-making aid improved identification of patients requiring transfer and streamlined the process of arranging the transfer. The authors of that study suggest that increased use of decision-making aids could reduce the overall time required for the transfer process,[7] an idea which has also been identified in a recent review of rural transport structures in BC.[8]

An example of a decision-making aid already implemented in other settings is the Early Warning Score (EWS). EWSs are tools allowing a set of vital signs to be condensed into a single numerical value, simplifying determination of a patient's severity and risk of subsequent adverse events. Vital sign components within an acceptable range are assigned the value zero, with increasingly large values assigned as the components become increasingly deranged. The component scores are then summed, such that an EWS higher than zero is associated with an increased risk of adverse events.[9] As the EWS rises, so does the risk, and a cut-off score is used to determine when the patient's risk has reached a level which requires intervention.

EWSs are most commonly used in track and trigger systems to recognise deteriorating patients on medical wards,[10] and their ability to predict outcomes including cardiac arrest, death, increased length of stay in hospital and upgrade to intensive care has been well validated in this setting.[11-13] In particular, a prospective study of 848 patients admitted to a high-acuity ward in the United Kingdom found that EWSs of four or greater were predictive of increased mortality and length of stay.[11]

The utility of EWSs in other settings has also been examined. A 2015 European study of 300 emergency room patients[14] found that an EWS was able to predict risk of admission, length of stay and death with greater accuracy than traditional triage methods. A 2012 retrospective chart review from the UK examined the ability of EWSs combined with clinical judgment in the prehospital setting to predict adverse patient outcomes.[15] The combination was found to have a sensitivity of 72.4% and specificity of 84.8% using a cut-off of four. Another retrospective chart review from the UK found that EWSs of seven or greater in the pre-hospital environment were associated with an increased risk of 48-h mortality, 30-day mortality and ICU admission.[16] Finally, two studies of transfers escorted by either nurses or physicians between large hospitals in Hong Kong found that higher EWSs are associated with physiological deterioration during transport.[17,18]

Following from previous, unpublished work by some of the present authors,[19,20] here we have conducted a pilot study examining the ability of an EWS to predict a selection of adverse outcomes in patients who presented to sending facilities in rural areas, as well as small and medium population centres, throughout Southeastern BC and were eventually transferred to larger receiving facilities for higher level care. Establishing the validity of EWSs in this setting is the first step in creating an EWS-based decision-making tool which can be used by both sending facilities and transport personnel.

METHODS

We conducted a secondary analysis using a dataset created via retrospective chart review. The dataset contains a broad range of information from acutely ill patients transferred between facilities spread across 215,000 square kilometres of the southern BC interior (population approximately 743,000).[21] All patients were transferred to one of the five receiving facilities for higher level care than was available locally and were transported by one of the four methods: ground basic life support (BLS) ambulance crew, air and ground critical care paramedic (CCP) ambulance crew, ground BLS ambulance crew with a doctor and nurse escort from the sending facility or a dedicated transfer team made up of a Registered Nurse (RN) and Registered Respiratory Therapist working with a ground BLS ambulance crew, known as a High Acuity Response Team (HART).[22,23]

Criteria for inclusion were being 16 years or older on admission, direct admission to the sending site emergency department, a Canadian Triage and Acuity Scale (CTAS) score of one or two at the receiving facility, transport between 20th November 2010 and 6th October 2014 and categorisation as neurological, cardiac, respiratory, sepsis or trauma. Eligible records were identified through an electronic patient database and selected randomly for data extraction, which was carried out at the five receiving facilities by a researcher and a clinician. When information was unavailable in the original patient care record, a RN and a paramedic, both with experience in interfacility transfers, attempted to infer it. If inference was not possible, the entry was left blank with no further data imputation. Validation was carried out on 20% of the data collected from one of the receiving facilities. The charts for validation were selected at random, and two research team members then compared them against the information in the database to confirm accuracy. Data collection and cleaning was completed using Microsoft Excel.

Standardised EWSs (SEWSs) were calculated from the patients' vital signs as per the method described by Paterson *et al*.[11] In brief, numerical scores were assigned to the patients' respiratory rate, oxygen saturation, temperature, blood pressure, heart rate and level of consciousness, with normal values scored zero and abnormal values scored from one to three, depending on the degree of abnormality. The sum of these six individual scores produced the SEWS. Patients were then grouped according to whether their SEWSs were <4 or were four or greater. Within-patient comparisons were made between the SEWS calculated from the first and last vital signs recorded by the sending facility, as well as the SEWSs calculated from the last vital signs recorded by the sending facility and the first recorded by the receiving facility. McNemar's test was used to determine if the number of patients with a SEWS of four or greater changed between these times, and Wilcoxon signed-ranks tests were used to determine if the average SEWS changed between these times.

The SEWS study groups (i.e., those with scores <4 and those with scores four or greater) were then compared against the following outcomes: the number of intervention categories during transport, an adverse event during transport, deterioration during transport, an adverse event within 30 min of arrival at the receiving facility, the length of stay at the receiving facility and death before discharge from the receiving facility [Box 1 for detailed definitions].

Chi-square tests were used to investigate the relationship between the SEWS and the following outcomes: an adverse event during transport, deterioration during transport, an adverse event within 30 minutes of arrival at the receiving facility, or death before discharge from the receiving facility. Pearson's chi-square test was used when the expected incidence in the sample was five or greater and two-tailed Fisher's exact test when the expected incidence was below five. The relationship between SEWS and outcome was described using relative risk. Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) were calculated for statistically significant results. The number of intervention categories required during transport and the length of stay at the receiving facility were both investigated using Mann–Whitney U-tests. The relationship between SEWS and outcome was described by comparing means.

All statistical analyses were carried out in IBM SPSS Statistics for Windows, version 23.0 (IBM Corp., Armonk, NY, USA), and $P < 0.05$ was considered as statistically significant.

The original data collection was carried out under an ethics application approved by the University of British Columbia in harmonisation with Interior Health.

Box 1: Definitions

- Adverse event during transport: A new, detrimental change in the patient's condition, ranging from oxygen saturation dropping below 88% to cardiac arrest
- Deterioration during transport: Having a final transport SEWS greater than the first transport SEWS
- Adverse event within 30 min of arrival at the receiving facility: A new, detrimental change in the patient's condition, ranging from oxygen saturation dropping below 88% to cardiac arrest
- Death before discharge from the receiving facility: Death at any time after activation of the transport team but before discharge from the receiving facility
- Number of intervention categories required during transport: A number from 0 to 5 for how many of airway, breathing, circulation, disability and other interventions were required. Only advanced procedures typical of a critical care environment (e.g., vasopressor administration) were included
- Length of stay at the receiving facility: Measured in days from when the patient arrived with the transport crew to when the patient left, rounded up to the nearest whole day

SEWS: Standardised Early Warning Score

Box 2: 2011 Canadian census definitions[31,32]

CA: Area with ≥1 municipalities around a core, population ≥10,000

CMA: Area with ≥1 municipalities around a core, population ≥100,000 with ≥50,000 in the core

Small population centres: Population 1000-29,999 and population density ≥400/km^2

Medium population centres: Population 30,000-99,999 and population density ≥400/km^2

Large urban population centres: Population >100,000 and Population density ≥400/km^2

CA: Census agglomeration, CMA: Census metropolitan area

RESULTS

The characteristics of the transfers contained within the dataset are described in Table 1[24-32] [Box 2 for an explanation of the 2011 Canadian census definitions].[33,34] Of the 418 patient entries in the dataset, 98 (23% of total) were missing one or more data points required for statistical analysis and were subsequently excluded on a test-by-test basis.

During the time between the first and final SEWS calculated at the sending site, the proportion of scores which were four or greater decreased from 24.8% to 14.8% ($P < 0.001$). Between the second and third SEWS, there was no significant change (14.8% and 17.0%, respectively, $P = 0.358$) [Figure 1].

A first SEWS of four or greater, calculated from the first vital signs recorded at the sending site, was associated with more intervention categories during transport (1 vs. 0, $P = 0.047$), an adverse event during transport ($P = 0.004$, risk ratio [RR] = 2.41, 95% confidence interval [CI] 1.32–4.39, sensitivity = 42%, specificity = 79%, PPV = 17%, NPV = 93%), an adverse event within 30 min of arrival at the receiving facility ($P = 0.004$, RR = 5.85, 95% CI 1.75–19.61, sensitivity = 64%, specificity = 78%, PPV = 7%, NPV = 99%) and death before discharge from the receiving facility ($P = 0.043$, RR = 2.29, 95% CI 1.01–5.18, sensitivity = 41%, specificity = 78%, PPV = 10%, NPV = 96%) as compared to a SEWS <4. There was no difference in deterioration during transport ($P = 0.105$, RR = 2.29, 95% CI 0.94–2.06) or the length of stay at the receiving facility (4.5 vs. 4, $P = 0.236$) between a SEWSs of four or greater or <4 [Tables 2 and 3].

DISCUSSION

The vast size of BC combined with ongoing regionalisation of health care has meant that the services required by rural patients with complex health problems are often not available at the closest hospital.[8,35] Accordingly, rural health care in BC is heavily dependent on interfacility transfers provided by ground or air ambulances.[3,36] This system is well used, with one study showing that 31% of trauma patients in Northwestern BC required interfacility transport to receive higher care.[4] The need for improvement in this system, however, has been identified by two recent works[8,23] and is signalled by the fact that rural British Columbians are still more likely to die after a traumatic injury than their non-rural counterparts.[4,37]

One possible approach to improving the outcomes of patients who require interfacility transport to receive higher level care is the implementation of decision-making aids for various steps in the transfer process.[7] While there are a variety of predictive tools to choose from, some, such as the Acute Physiology And Chronic Health Evaluation II score,[38] require information from laboratory investigations that may not be readily available in rural BC hospitals or during transport.[3] EWSs, on the other hand, require only

Table 1: Characteristics of transfers included in dataset (*n*=418)

Parameter	*n* (%) or median (IQR)
Sending facility by community location (%)	
Rural (outside CMA/CA)	343 (82.1)
Inside CA	75 (17.9)
Inside CMA	0 (0.0)
Sending facility by community population (%)	
Pop < 1,000	51 (12.2)
1,000-9,999	276 (66.0)
10,000-29,999	73 (17.5)
30,000-99,999	18 (4.3)
Time at sending facility (h)	3.54 (2.14-5.94)
Transport distance (km)	107 (72-133)
Transport time (min)	74 (50-100)
Transport crew type (%)	
Ground BLS crew	159 (38.0)
CCP crew	25 (6.0)
Ground BLS crew w/escort	34 (8.1)
HART	200 (47.9)
Patient age (years)	60 (47-71.25)
Patient sex (%)	
Male	278 (66.5)
Female	140 (33.5)
Classification (%)	
Neurological	68 (16.3)
Cardiac	157 (37.6)
Respiratory	68 (16.3)
Sepsis	24 (5.6)
Trauma	101 (24.2)

CA: Census agglomeration, CMA: Census metropolitan area, BLS: Basic life support, CCP: Critical care paramedic, HART: High-acuity response team, IQR: Interquartile range.

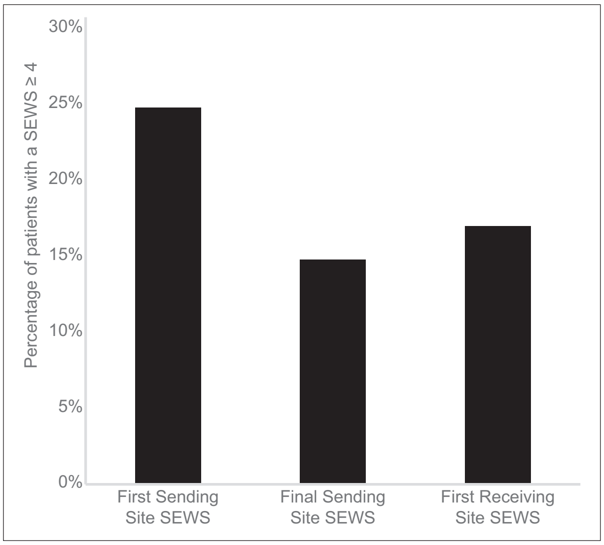

Figure 1: Proportion of patients with a Standardised Early Warning Score of 4 or greater measured at three times: the first time vital signs were recorded at the sending site, the last time vital signs were recorded at the sending site, and the first time vital signs were recorded at the receiving facility. The difference between the first and second sending site is significant ($P < 0.001$) but the difference between the second sending site and first receiving facility is not ($P = 0.358$).

Table 2: Associations between a Standardised Early Warning Score of four or greater calculated from the first set of vital signs taken at the sending facility and dichotomous outcomes

Outcome	Significance (*P*)	RR (95% CI)	Sensitivity	Specificity	PPV	NPV
Adverse event during transport	0.004	2.41 (1.32-4.39)	0.42	0.79	0.17	0.93
Deterioration during transport	0.105	1.39 (0.94-2.06)				
Adverse event within 30 min of arrival at receiving facility	0.004	5.85 (1.75-19.61)	0.64	0.78	0.07	0.99
Death before discharge from the receiving facility	0.043	2.29 (1.01-5.18)	0.41	0.78	0.10	0.96

Sensitivity, specificity, PPV and NPV are shown for significant outcomes. RR: Relative risk, CI: Confidence interval, PPV: Positive predictive value, NPV: Negative predictive value.

Table 3: Associations between the Standardised Early Warning Score calculated from the first set of vital signs taken at the sending facility and ordinal outcomes

Outcome	Significance (*P*)	Median (IQR)	
		SEWS <4	SEWS ≥4
Number of intervention categories required during transport	0.047	0 (0-2)	1 (0-3)
Length of stay at the receiving facility (days)	0.236	4 (2-8)	4.5 (2-11.25)

IQR: Interquartile range, SEWS: Standardised Early Warning Score.

the patient's vital signs, which are easily obtained at any health facility, or by any transport crew. Here, we have evaluated the ability of the SEWS[11] to predict a selection of outcome measures among patients who underwent interfacility transfers from sending facilities throughout the southern BC interior.

While numerous studies have used the area under the receiver operating characteristic curve to identify the optimal cut-off score to use with a particular EWS,[15-17,39-42] the objective of this pilot study was to evaluate the usefulness of a previously validated EWS and cut-off value. The SEWS was chosen because it has performed well when compared against other EWSs[41] and could be calculated from the available data.

We began by examining the proportion of patients who had a SEWS of four or greater over three time periods: two at the sending site and one at the receiving facility. The decrease in proportion between the first and second time periods from 24.8% to 14.8% represents a drop of 40.3%. We view this as an indication that sending facilities in rural areas, as well as small and medium population centres, have an important ability to improve a patient's condition before transport despite not being able to provide the full level of care required. This interpretation is consistent with the findings of Belway *et al*.[43] who examined the outcomes of patients transferred from smaller hospitals to the ICU or critical care unit (CCU) of larger hospitals in BC. They found increased time at the sending facility was associated with a decreased length of stay in the ICU or CCU, an outcome they attributed to improved pre-transport stabilisation. The potential for the sending site to improve the patient's condition before transport also highlights the importance of education and support for rural staff, previously identified by others.[4,8] Our failure to detect a difference between the final SEWS from the sending site and the first SEWS from the receiving site suggests that crews are maintaining the improvements achieved at the sending facility and adequately managing new problems as they arise.

A SEWS of four or greater was associated with all outcomes except deterioration during transport and length of stay at the receiving facility. The definition of deterioration during transport used here [Box 1] was a novel one we have not seen elsewhere in the literature. Because the SEWSs used to calculate deterioration were temporally proximate to the final SEWS from the sending site and the first SEWS from the receiving site, it is not surprising that this measure also failed to show a change over time. It seems likely that the transport crews are successfully correcting any deterioration of the patient's condition as it happens, and as a result, the final transport SEWS ends up very similar to the initial transport SEWS, regardless of brief variations in between. The inability of the SEWS to predict length of stay at the receiving facility was unexpected, as it has previously been shown to perform well on this measure in a selection of 848 patients admitted to a medical/surgical combined assessment area.[11] It is possible that it was unable to do so here because of complicating factors unique to rural interfacility transfers. These may include the lack of clinical resources required to support long-distance repatriations to the communities represented in this dataset, or the geography over which the transfers must take place.[8]

The association between a SEWS of four or greater and both adverse events during transport and the number of interventions required is consistent with the findings of Wong *et al*. in an urban setting.[17] They examined the ability of the Modified EWS (MEWS) to predict complications during interfacility transfers originating in the accident and emergency department of Pok Oi Hospital in Hong Kong, and showed that the MEWS calculated from vital signs obtained at triage were best able to do this. Here, we have found the relative risk of an adverse event during transport for patients with a SEWS of four or greater to be 2.41, with a sensitivity of 42% and specificity of 79%. These values are similar to those found by Lee *et al*.[18] using the MEWS with a cut-off score of 3 to predict deterioration during interfacility transfers originating in the emergency room of Alice Ho Miu Ling Nethersole Hospital in Hong Kong (43% and 78%, respectively). With 68% of rural BC hospitals more than 300 km from a level II trauma centre,[3] prior knowledge of a patient's risk for these outcomes could form a valuable part of the transport team's pre-planning, as well as play a role in decisions about what level of transport team to activate.

The SEWS was also able to predict two receiving facility outcomes. An adverse event within 30 min of arrival at the receiving facility was the outcome most strongly associated with a SEWS of four or greater, with a relative risk of 5.85, a sensitivity of 64% and a specificity of 78%. These values are similar to those reported by Fullerton *et al*. (71% and 76%, respectively)[15] using the MEWS with a cut-off of 3 in the pre-hospital environment to predict an adverse event within 24 h of arrival. Patients with a SEWS of four or greater also had an elevated risk of death before discharge from the receiving facility, with a relative risk of 2.29, sensitivity of 41% and specificity of 78%. While not as impressive as the 8-fold increase in mortality among these patients observed by Paterson *et al*.,[11] any advanced warning about an outcome of this severity can be helpful in making decisions about patient care.

Overall, the performance of the SEWS here is similar to other EWSs in other patient transport environments. Because this study uses a database of patients who were transferred from one facility to another, clinical judgment had already been applied to recognise the need for higher level care and the risk of deterioration. What we have demonstrated is that, among these pre-selected patients, using the SEWS with a cut-off of four offers a reasonably specific means of identifying those with the greatest and most immediate need for close monitoring and care. This points towards several potential uses for the SEWS in the rural setting, including confirming clinical gestalt about the urgency of a transfer, aiding in decisions about which type of transport crew to dispatch and alerting transport crews and receiving facilities to those patients likely to require the most care.

Limitations

As a pilot study, the sample size here (n = 418) is relatively small, limiting its power, particularly when examining rare outcomes such as death before discharge.

While the modes of transport included in this dataset represent the full spectrum of acute interfacility transfers within the study area, the frequency of each within the study area was not determined, so the proportions in this sample are likely not representative. This has the most bearing on the number of intervention categories required during transport because these were generally above the scope of practice of ground BLS crews, introducing the possibility of values >0 being inappropriately rare or common.

The data used in this study were extracted from clinical records rather than documents prepared specifically for research. Consequently, there were variations in both the recording style and completeness of the information. While experienced clinicians attempted to infer unclear or missing values where reasonable, this was often not possible, requiring cases to be excluded for particular tests, and it is unknown what effect this has had on the results.

Moving forward, it is important to validate these findings with a larger, prospective study conducted in the same environment and utilising a random sampling of all comers to sending facilities in rural areas, as well as small and medium population centres. This will allow evaluation of the SEWS's ability to inform the initial decision to transport patients for a higher level of care in addition to the subsequent decisions considered here.

CONCLUSION

Here, we have examined the potential of the SEWS to inform decisions about patient care and disposition when transferring patients from sending facilities in rural areas, as well as small and medium population centres, to larger receiving facilities, to receive a higher level of care. Within the limitations of this pilot study, we have found its performance to be similar to that of other EWSs in urban interfacility or pre-hospital environments. This opens the door to using the SEWS as part of the planning process and risk stratification for transfers from these sending facilities. In addition, we have found that the average SEWS generally decreases over the time patients spend at the sending facility, highlighting the important role sending facility staff play in patient stabilisation.

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